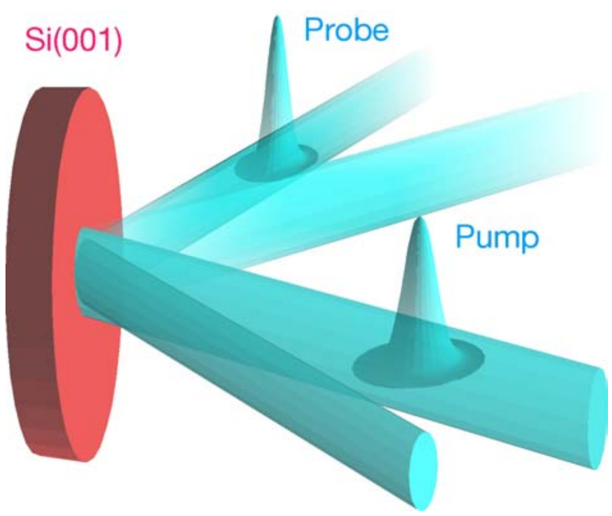
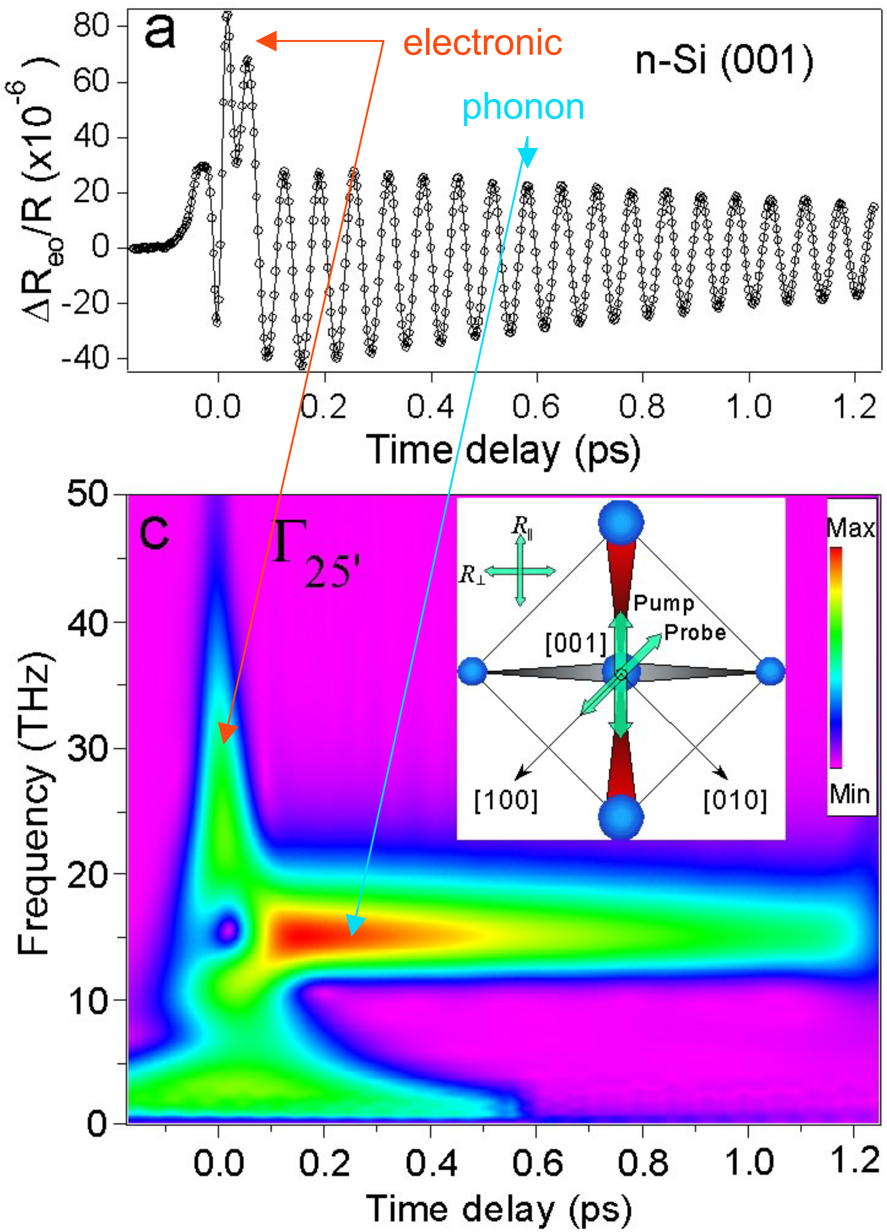
The coherent response of Si to an optical impulse

An external optical field drives coherent charge oscillations in solids that decay on a few femtosecond (10^{-15} s) time scale due to the scattering of carriers among themselves and with the lattice ions. While the light-matter interaction is coherent, we can apply internal fields and forces that are directly given by the phase and amplitude of the external field, and thereby control the properties of matter. With a unique Ti:sapphire laser producing 10 fs pulses at 400 nm, which was constructed as a part of NSF-MRI project, we investigate the transient anisotropic reflectivity (see below) from Si(001) surface. The reflectivity shown on the next slide is modulated by the coherent electronic response of <100 femtosecond time scale, and by the coherent longitudinal optical phonon oscillation at 15.3 THz. Our ability to resolve the electronic response indicates that it may be possible to perform opto-electronic information processing in Si at >10 THz bandwidths.

This research was performed at the University of Pittsburgh in collaboration with physicists from the National Institute of Materials Science in Tsukuba, Japan.



Transient reflectivity - 10 fs laser pump pulse induces changes in the index of refraction of silicon modulating the reflectivity of the delayed probe pulse.



Transient anisotropic reflectivity from Si(001)

Top. The anisotropic reflectivity signal from Si with pump and probe pulse polarization alignment relative the crystal axis shown in the insert.

Bottom. The continuous wavelet transform of the reflectivity data displays the coherent response in time-frequency space. The vertical going signal near zero delay is the electronic response and the horizontal signal at 15.3 THz is the coherent phonon response. In the overlap region the signal amplitude vanishes due to interference between the two responses.